Acoustic Daylight Imaging

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LONG-TERM GOALS

The objective is to produce high quality, moving colour images of objects in the ocean and on the sea floor, using ambient noise from wind-driven and biological sources as the only source of acoustic illumination. Imaging breaking surface waves from below is also an important objective, with a view to establishing the acoustical properties of bubble clouds as they evolve in time, frequency and space. The imaging technique is covert, with the potential for imaging partially buried and proud mines in shallow water, up to and including the surf zone. Other possible applications include harbour entrance monitoring, moored-ship defence, and structural-integrity diagnosis of off-shore platforms.

SCIENTIFIC OBJECTIVES

Two scientific objectives are addressed: ambient noise imaging of a variety of planar and volumetric targets located in mid-water column, resting on the seafloor, and partially buried in the sediment; and mapping the acoustic source regions of breaking surface waves. The targets include flat and curved geometrical shapes with a variety of acoustic surfaces, and barrel-like objects filled with materials of differing acoustic impedance (syntactic foam, wet sand, and sea water). Deployments of the Acoustic Daylight Ocean Noise Imaging System (ADONIS) from R/P Flip are an essential part of the wave-breaking program. The at-sea tests are intended to produce moving, color images of the targets and breaking waves in real time.

APPROACH

Ambient noise imaging is a concept that has been developed at SIO over the past five years, supported by the ONR 6.1 Ocean Acoustics program. An acoustic reflecting dish (ADONIS) has been built which provides moving, color, real time images of 126 pixels, with a frame rate of 25 Hz. The system has a unique capability, allowing silent objects to be recorded in a video-like format, without the need for a dedicated sound source. ADONIS consists of a 3m spherical reflector with an array of 126 hydrophones in the focal surface. The dish is mounted on a mast containing a coaxial hydraulic motor, which allows the lens to be panned around in azimuth.

The ADONIS dish is deployed in two ways: off Point Loma on R/P ORB, to perform imaging of targets using mainly noise from snapping shrimp; and mounted on R/P FLIP for passive acoustic imaging of breaking waves, as seen from below. In support of the ORB deployments, extensive studies of the spatial and temporal statistics of snapping-shrimp pulses have been conducted, with a view to

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exploiting the information to improve image quality. Many different types of targets have also been deployed from ORB at ranges up to 80 m, although most data were collected at a range around 40 m.

ADONIS has also been mounted on the hull of FLIP and used to image the acoustic structure of breaking waves passing overhead. With the vessel in the vertical orientation, the dish was approximately 30 m below the surface. The hydraulic motor allows the dish to be directed up towards the surface remotely, at a slant angle of about 45˚. A conventional video camera monitors the breaking waves from above, for later correlation with the acoustic data. Data are recorded continually onto a large hard drive and later transcribed to CD ROM for permanent storage.

WORK COMPLETED

A major deployment of ADONIS on ORB, lasting about six weeks, yielded extensive data sets containing images of a variety of targets in the water column and on the seabed. A further deployment of ADONIS on FLIP some twenty kilometres off the coast of San Diego was successful in providing acoustic images of breaking waves in fairly calm conditions. Extensive data sets selected from both deployments have been analyzed and moving, colored images produced.

ACCOMPLISHMENTS AND RESULTS

A variety of targets suspended at mid-depth in the water column has been successfully imaged. It has been demonstrated that containers with different contents (e.g., wet sand and syntactic foam) appear as different colors in the images. This has been achieved by exploiting the broad band nature of ADONIS. PVC barrels containing various materials, including wet sand, have been recorded on the seafloor, against a background consisting of fine sediment. The extremely large data set (stored on 70 CD ROMs) collected during the second deployment of ADONIS from ORB has been examined and selected portions of the data have been analyzed.

Another extensive data set, on breaking waves, has been collected from FLIP. The resultant images show the first high-resolution views of the internal acoustic structure of breaking waves. These images yield interesting and important insights into the details of air entrainment and gas transfer processes occurring at the air-sea interface during wave breaking.

Examples of both still and moving Acoustic Daylight images can be seen on the web at the above URL. A paper discussing the Acoustic Daylight data has been submitted to the Journal of the Acoustical Society of America[1]; and a second article has appeared in Scientific American[2], which describes the Acoustic Daylight concept. A number of papers on various aspects of acoustic daylight imaging have also been published in the scientific literature[1, 3-13].

The Scientific American article was awarded the Acoustical Society of America’s SCIENCE WRITING AWARD for Professionals in Acoustics. Our ADONIS high resolution, multi-beam receiver was a FINALIST in the Discover Magazine Awards for Technological Innovation, Orlando, Florida, June 1998 (Sight category).

Several articles have appeared recently on our Acoustic Daylight research in a number of popular technical journals, magazines and newspapers [GEO magazine, Christian Science Monitor, Discover Magazine, The Sunday Times (London), etc.]. Acoustic Daylight was also featured on the BBC World

Service science program “Science Now”, in April 1998. Acoustic Daylight has also been the subject of a couple of television science documentaries: World of Wonder on the Discovery Channel; and PRISMA, German Public Television, NDR, broadcast on October 27 1998.

IMPACT/APPLICATIONS

Acoustic Daylight offers the potential for COVERT imaging in numerous applications of interest to the navy. For instance: detection of mines in the littoral zone; harbour entrance monitoring; providing forward vision on a UUV.

TRANSITION/INTEGRATION

No transitioning has yet been achieved, but I am currently discussing possible ways of transitioning with Don Ream, SPAWAR Systems Center, San Diego.

INTERNATIONAL COLLABORATION AND RESEARCH

Australia

1. The Defence Science and Technology Organisation (DSTO), Sydney is funding a substantial research program into Acoustic Daylight imaging (Dr. Mark Readhead).

2. Curtin University, Perth is investigating Acoustic Daylight imaging and will be working with SIO and DSTO in a collaborative research effort (Dr. John Penrose).

United Kingdom

1. The Defence Research Agency, Winfrith has recently invested major funding in an Acoustic Daylight development program (Dr. Alastair Cowley). We are working closely with them on their acoustic daylight research. In December 1999, the Winfrith group will be conducting acoustic daylight experiments in La Jolla, off Scripps Pier, using the ADONIS system that we developed at Scripps with ONR support.

Singapore

1. The Ministry of Defence is funding an extensive Acoustic Daylight research program (Dr. Philip Chan).

India

1. The National Institute of Ocean Technology has recently received funding to investigate Acoustic Daylight imaging (Dr. Ardhendu Pathak).

2. Daimler Benz research Centre is conducting experiments on Acoustic Daylight imaging (Dr. Samta Bansal).

3. CSIR Centre for Mathematical Modelling and Computer Simulation (Dr. R. N. Singh).

Argentina

1. Naval Service, Research and Development is pursuing research on Acoustic Daylight (Dr. Marta Milou).

Germany

1. The Federal Government of Germany has expressed interest in developing an Acoustic Daylight capability (Prof. Peter Wille).

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